

# Additional data from clinical examination on site significantly but marginally improve predictive accuracy of the Revised Trauma Score for major complications during Helicopter Emergency Medical Service missions

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## Abstract

**Introduction:** The Revised Trauma Score (RTS) accurately identifies trauma patients at high risk of adverse events or death. Less is known about its usefulness in the general population and non-trauma recipients of Helicopter Emergency Medical Service (HEMS). The RTS is a simple tool and omits a lot of other data obtained during clinical evaluation. The aim was to assess the role of the RTS to identify patients at risk of major complications (death, cardiopulmonary resuscitation, defibrillation, intubation) in the general population of HEMS patients. Clinical factors beyond the RTS were analyzed to identify additional prognostic factors for predicting major complications.

**Material and methods:** A retrospective analysis of medical records of adult patients routinely collected during HEMS missions in the years 2011–2014 was performed.

**Results:** The analysis included 19 554 HEMS missions. Patients were 55 ±20 years old and 68% were male. The most common indication for HEMS was diseases of the circulatory system – 41%. Major complications occurred in 2072 (10.6%) cases. In the general population of HEMS patients, the RTS accurately identified individuals at risk of major complications at a cut-off value of 10.5 and area under the curve (AUC) of 93.5%. In multivariate analysis, additional clinical data derived from clinical examination (ECG; skin, pupil and breathing examination) significantly but marginally improved the accuracy of RTS assessment: AUC 95.6% ( $p < 0.001$  for the difference).

**Conclusions:** The Revised Trauma Score accurately identifies individuals at risk of major complications during HEMS missions regardless of the indication. Additional clinical data significantly but marginally improved the accuracy of RTS in the general population of HEMS patients.

**Key words:** Helicopter Emergency Medical Service, Revised Trauma Score, risk, major complications, general population.

## Introduction

The general purpose of Helicopter Emergency Medical Services (HEMS) is to deliver a highly specialized professional emergency team to patients demanding acute medical treatment in situations requiring the shortest possible time to deliver definitive care, or to provide transport to patients inaccessible by other means [1]. Helicopter Emergency Medical Services is widely considered very effective in the transportation of trauma or cardiac arrest patients. It is also cost-effective in those settings [2–11]. At the site of an emergency, HEMS teams lack the diagnostic infrastructure of a hospital; hence in order to assess the clinical state of the patient, they have to rely mostly on the patient's history and on physical examination. What is more, HEMS teams may differ in the proficiency of performing critical care procedures [12]. Widely recognized scales (Glasgow Coma Scale – GCS; Revised Trauma Score – RTS; National Advisory Committee on Aeronautics' severity score – NACA) help to identify high-risk patients based on basic signs and symptoms, but they omit a lot of other data obtained during clinical evaluation [13–18]. Extensive evaluation of the RTS concentrated on trauma patients, while lacking data concerning other HEMS patients [1, 19–25].

The aim of this study was to assess the role of the RTS as a screening tool to identify patients at risk of major complications (death, cardiopulmonary resuscitation, defibrillation, intubation) during all HEMS missions. Clinical factors beyond the RTS were also analyzed to identify their additional prognostic value in the prediction of major complications.

## Material and methods

This study was a retrospective analysis of medical records of adult patients routinely filled out during HEMS missions in Poland in the years 2011–2014. Since those records are mandatory and a copy of the record is attached to the medical history of the patient after the mission, clinical data derived from those records rarely miss significant clinical information.

We extracted the data on general information (age, gender), history and physical examination comprising general appearance and skin examination (pallor, cyanosis, jaundice, any abnormal color), pupil diameter and reaction to light, meningeal signs, convulsions, palsy/paresis, breathing rate and sounds, and the RTS. The dataset was supplemented by rhythm assessment based on the 12-lead ECG. The indication for HEMS intervention was described according to International Classification of Diseases three-letter codes.

The primary endpoint of the analysis was the occurrence of a major complication during the HEMS mission defined as any of the following: death or need of cardiopulmonary resuscitation, defibrillation or intubation (if not performed before).

## Statistical analysis

Normally distributed continuous data are presented as mean  $\pm$  standard deviation. Categorical variables are summarized as frequencies and percentages.

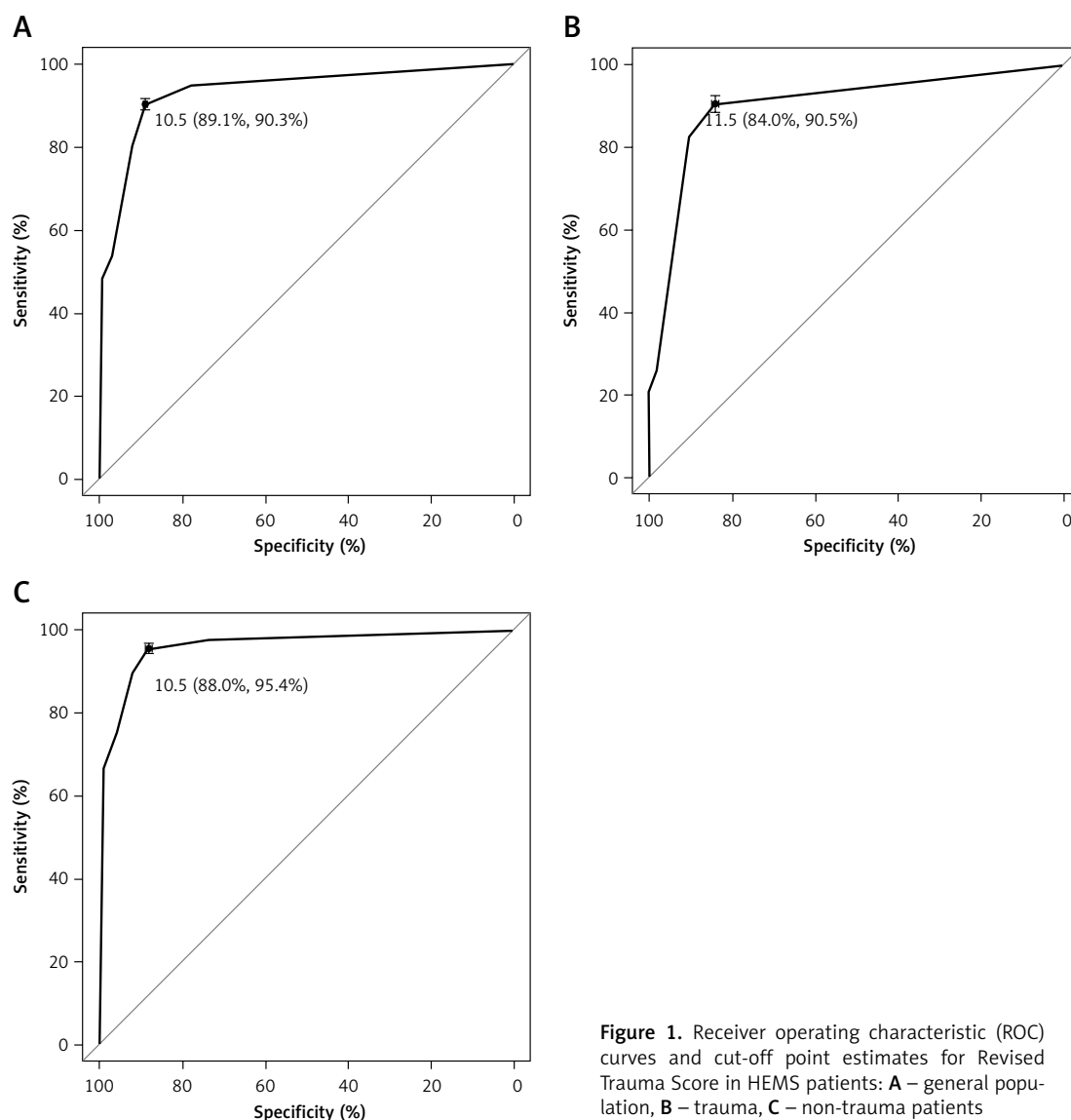
Logistic regression analysis was used to analyze the impact of potential factors on the risk of complications. The usefulness of the RTS scale and prediction from a multivariate model was assessed using the analysis of ROC curves. Analysis was performed using R 3.1.2 statistical software. ROC curve computations were done using the pROC package [26].

## Results

In the years 2011–2014 there were 19 554 HEMS missions in Poland. Patients were  $55 \pm 20$  years old (range: 18–113 years) and 68% were male. The most common indications for HEMS were diseases of the circulatory system (code I according to ICD-10) (41% of the missions), followed by injury, poisoning and certain other consequences of external causes (code S) (23%) and external causes of morbidity and mortality (code T) (8%). In 79.2% of the cases, the initial assessment and treatment of the patient were performed by professional rescuers before HEMS arrival. The average GCS, RTS and NACA scores were  $12.5 \pm 4.2$ ,  $10.7 \pm 3.1$  and  $4.2 \pm 1.1$ , respectively. The mean time from notification to HEMS arrival on the scene was  $24.2 \pm 16.2$  min, and the mean time of a HEMS mission was  $40.6 \pm 17.6$  min. The composite primary endpoint occurred in 2072 (10.6%) patients; the incidence of components of the primary endpoint was: death 976 (10.6%), intubation 1423 (7.3%), need of cardiopulmonary resuscitation 907 (4.6%) and defibrillation 240 (1.2%).

The optimal cut-off value for the RTS in the general population of HEMS patients differentiating between patients with and without the primary endpoint was 10.5. The cut-off value for the trauma patients was 11.5, and the cut-off for other (non-traumatic) patients was 10.5 (Figure 1).

The results of the multivariate analysis are summarized in Table I. In comparison to RTS alone, data derived from the skin, breathing and pupil examination together with ECG findings significantly but only marginally improved identification of patients at risk of the primary endpoint. What is more, they were by far the most common-



**Figure 1.** Receiver operating characteristic (ROC) curves and cut-off point estimates for Revised Trauma Score in HEMS patients: **A** – general population, **B** – trauma, **C** – non-trauma patients

ly noted abnormalities in physical examination. The only factors decreasing the risk of the primary endpoint were higher RTS, older age and disease of the respiratory system. About 79% of the patients received professional help before the HEMS, and it appeared to be a risk factor for an unfavorable outcome of the mission.

The area under the curve (AUC) calculations for the RTS score alone and the RTS with additional variables selected from Table I are shown in Table II. Respective receiver operating characteristic (ROC) curves are presented in Figure 2. The addition of data from clinical examination significantly improved AUC ( $p < 0.0001$ ) and marginally changed the sensitivity and specificity of predicting an unfavorable outcome.

## Discussion

Our study was developed and conducted to support HEMS teams with the rapid assessment

of risk of death or need for cardiopulmonary resuscitation, defibrillation or intubation during the mission based on a basic clinical examination and general information about the patient. To our knowledge, this is the first study exploring the prognostic roles of the RTS and other clinical factors for utilization not only in traumatic but in the whole population for HEMS missions.

There were medical records of almost twenty thousand HEMS missions. It was well known that a low RTS score indicated poor outcomes, but those findings were limited to trauma patients and this scale did not take into account the abundance of data derived from clinical examination [2, 5, 8, 12, 13, 19, 22, 23]. We showed that the RTS is a simple and reliable tool for the identification of patients at risk of major complications during HEMS missions in a cohort where trauma patients accounted for roughly 40% of all the cases, and the score was found to be applicable for

**Table I.** Signs, symptoms, demographic and clinical data examined or acquired during HEMS missions and the outcomes. Multivariate analysis

Variable	N	%	OR	95% CI	P-value
RTS (for every 1 point increase)			0.957	(0.955–0.959)	<b>&lt; 0.001</b>
Age (for every 10 years increase)			0.997	(0.996–0.999)	0.042
Male gender	13264	67.8	1.004	(0.997–1.011)	0.253
Treatment before HEMS	15477	79.1	1.015	(1.007–1.023)	<b>&lt; 0.001</b>
Skin:					
Abnormal color	5626	28.7	1.024	(1.016–1.033)	<b>&lt; 0.001</b>
Moist	3257	16.6	1.012	(1.003–1.021)	<b>0.012</b>
Central cyanosis	502	2.5	1.012	(1.003–1.021)	<b>0.012</b>
Peripheral cyanosis	353	1.8	1.012	(1.003–1.021)	<b>0.012</b>
Breathing:					
Lack of breathing sounds	751	3.8	1.065	(1.046–1.085)	<b>&lt; 0.001</b>
Dyspnea	2363	12.1	1.048	(1.035–1.06)	<b>&lt; 0.001</b>
Abnormal breathing sounds	2145	10.9	1.043	(1.032–1.055)	<b>&lt; 0.001</b>
Neurological signs:					
Convulsions	1225	6.2	1.026	(1.006–1.047)	<b>0.013</b>
Meningeal signs	985	5.0	1.022	(0.995–1.051)	0.113
Paralysis/Palsy	3913	20.0	0.997	(0.989–1.006)	0.552
Pupil (at least one):					
Abnormal reaction to light	3545	18.1	1.058	(1.043–1.073)	<b>&lt; 0.001</b>
Abnormal size	4959	25.3	1.033	(1.023–1.044)	<b>&lt; 0.001</b>
ECG:					
Asystole	716	3.6	1.506	(1.466–1.547)	<b>&lt; 0.001</b>
PEA	220	1.1	1.427	(1.378–1.479)	<b>&lt; 0.001</b>
VT/VF	152	0.7	1.480	(1.423–1.54)	<b>&lt; 0.001</b>
Bradycardia	196	0.1	1.096	(1.062–1.13)	<b>&lt; 0.001</b>
SVT	892	4.5	1.025	(1.01–1.04)	<b>0.001</b>
Atrial fibrillation/flutter	1369	7.0	0.994	(0.982–1.007)	0.381
Stimulation	118	0.6	0.990	(0.953–1.029)	0.624
AV block (any)	124	0.6	0.984	(0.947–1.022)	0.398
PVC/nsVT	131	0.6	0.980	(0.945–1.016)	0.274
Disease groups according to ICD-10:					
I – Circulatory system	7973	40.8		Reference	
J – Respiratory system	270	1.4	0.95	(0.923–0.977)	<b>&lt; 0.001</b>
T – Injury, poisoning and certain other consequences of external causes	3441	17.6	1.049	(1.038–1.059)	<b>&lt; 0.001</b>
S – Injuries	4492	23.0	1.031	(1.022–1.041)	<b>&lt; 0.001</b>
R – Not elsewhere classified	1597	8.2	1.024	(1.011–1.036)	<b>&lt; 0.001</b>
V – Transport accidents	370	1.9	1.037	(1.014–1.061)	<b>0.002</b>
G – Nervous system	481	2.5	0.996	(0.975–1.017)	0.715
W – External causes of morbidity	268	1.4	1.01	(0.984–1.037)	0.453
Other	661	3.4	1.003	(0.985–1.021)	0.776

RTS – Revised Trauma Score, HEMS – helicopter emergency medical services, PEA – pulseless electrical activity, VT/VF – ventricular tachycardia/fibrillation, PVC/nsVT – premature ventricular extrasystole/non-sustained ventricular tachycardia, SVT – supraventricular tachycardia. **Bold** characters used for factors with statistical significance; ICD-10 – International Classification of Diseases.

**Table II.** Comparison of the area under the curve (AUC) and corresponding sensitivity and specificity for the standard RTS score vs. the RTS + additional variables

Variable	AUC* (%)	Sensitivity** (95% CI)	Specificity** (95% CI)
RTS	93.5	90.4 (88.9–91.62)	89.1 (88.6–89.5)
RTS + additional variables	95.6	92.3 (91.1–93.5)	87.7 (87.2–88.2)

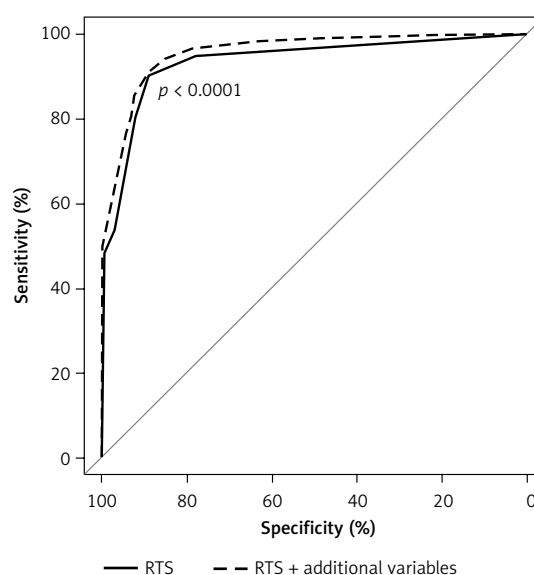
\* $P < 0.0001$  for difference; \*\*for cut-off point maximizing sum of sensitivity and specificity. AUC – area under the curve, RTS – Revised Trauma Score.

non-traumatic patients as well. The ROC curve analysis showed the AUC value of 93.5%.

We calculated the optimal RTS cut-off value of 10.5 for major complications in an unselected population of HEMS. This is similar but a little lower than in publications regarding pure trauma patients, where the score  $< 12$  already indicated patients with major trauma or at risk of death [20, 21]. Other studies reported data on mortality alone with a cut-off value of  $< 5$  or  $< 5.5$  [19, 22].

Most of our other findings may seem somewhat intuitional: pale skin, cyanosis and tachycardia were indicators of imminent or developed shock, and the inappropriate diameter of the pupil and abnormal reaction to light might indicate severe head trauma. Incorporation of these data into a multivariate model together with the RTS resulted in a statistically significant improvement in the identification of patients at risk of an unfavorable course of a HEMS mission. The incorporation of additional variables into the model improved the prediction of complications slightly, but statistically significantly. The AUC value was 95.6%.

As shown above, the RTS alone was very precise in selecting patients at risk of the composite primary endpoint. The addition of other signs and symptoms derived from the physical examination significantly but only marginally improved selection of patients at risk. From the clinical point of view, this additional benefit may be of minor importance. Our study supports the claim that it is necessary for HEMS teams to interpret the standard 12-lead surface ECG [1, 17–22, 25]. While the sinus rhythm was present in about 75% of cases, almost any regular brady- or tachyarrhythmia was a risk factor for the primary end point, not to mention asystole or malignant rhythms demanding urgent cardioversion or defibrillation. Irregular rhythms and simple ventricular premature contractions were not significantly related to any outcome. It is worth mentioning that the most common arrhythmia in our study – regular supraventricular tachycardia (4.5% of cases) – was also related to the primary outcome (OR = 1.025;



**Figure 2.** Receiver operating characteristic (ROC) curves for comparison of the Revised Trauma Score (RTS) (continuous line) vs. the RTS + additional variables (dashed line) in general population of HEMS patients

RTS – Revised Trauma Score.

95% CI: 1.01–1.04) and may be interpreted as one of the classical prodromal signs of hemodynamic shock [27].

One of the interesting and unexpected findings of this study was the worse prognosis for patients treated before HEMS arrival, which applied to almost 80% of cases. The simplest explanation for this situation seems to be that those patients were in a worse clinical status. The issue of pre-HEMS treatment requires further investigation, which is beyond the scope of this study. Other findings requiring further analysis are the influence of age and initial diagnosis of a respiratory system disease on the lower risk of primary end-points.

This is a retrospective study based on data derived from standard medical records, and therefore the standard limitations of those studies apply to our analysis. To minimize the influence of potential cofounders we used all the available records. We did not analyze the influence of the patients' clinical status or of HEMS procedures on long-term outcomes. This analysis was performed solely to aid HEMS teams to stratify the risk of an unfavorable course of missions. The data concerning in- and out-of-hospital outcomes of patients were not part of the HEMS medical documentation.

In conclusion, the Revised Trauma Score identified individuals at risk of major complications during HEMS missions regardless of the indication for the mission. Additional clinical data (ECG; skin, pupil, breathing examination) significantly but marginally improved the accuracy of the Re-

vised Trauma Score in the general population of Helicopter Emergency Medical Services patients.

# Conflict of interest

The authors declare no conflict of interest.

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